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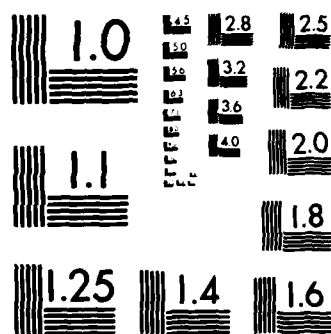
15 MICROMETER GAINASP HIGH PULSED POWER DIODE LASERS
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| 20. ABSTRACT (Continue on reverse side if necessary and identify by block number) The growth condition for fabricating 1.5 um lasers using LPE techniques has been established. High power performance and external quantum efficiency of the laser are studied. | | |

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1.5 MICROMETER GaInAsP HIGH PULSED POWER DIODE LASERS

FINAL REPORT

J. JIM HSIEH

4 MARCH 1985

U.S ARMY RESEARCH OFFICE

CONTRACT NUMBER DAAG29-81-C-0036

LASERTRON, INC.

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1.5 Micrometer GaInAsP High Pulsed Power Diode Lasers

4 March 1985

Lasertron, Inc.

FOREWORD:

Lasertron undertook a three year experimental research project to study the physics of quaternary GaInAsP lasers operating at wavelengths near 1.5 micrometers. The program included 1) studies of the LPE growth process including heterostructure interface anomalies associated with substrate dissolution during growth, 2) studies of optical cavity structures to optimize output pulsed power, 3) studies of techniques for integrating multijunction emission into a single output beam.

PROBLEMS STUDIED:

Three basic problems are studied in the development of 1.5 um lasers using the LPE technique. The first is a materials preparation problem. When LPE is used for the preparation of the InP/GaInAsP/InP double-heterojunction (DH) lasers dissolution of the grown layers may occur if the condition of the growth is not precisely controlled. In the study the growth of the 1.5 um GaInAsP layer was investigated against the growth temperatures in lattice matched conditions. When the growth temperature was determined for the best quality GaInAsP layer the condition was used to grow the DH structure for the lasers. In the study of the growth of the DH lasers the conditions of dissolution with or

without an antimelt-back buffer layer was also determined. The result of this study was the ability for us to grow DH lasers with wavelengths anywhere in 1.50 to 1.57 μm range.

The second problem was the determination of the laser structure aiming at high external quantum efficiency, low power dissipation, and good beam quality. Simple, conventional oxide-defined stripe geometry lasers have been fabricated. This type of laser is easy to fabricate, however, it suffers from high threshold currents (200-400 mA) and mode instability at high drive currents. The latter part of the study has been concentrated on the fabrication of buried heterostructure (BH) lasers. In particular, we are interested in fabricating the BH lasers with only one LPE step because LPE is one of the most critical and low yield processes. We have achieved the result by using thermal mass-transport techniques, as the first to use mass-transport in fabricating 1.5 μm lasers.

The other problem in dealing with GaInAsP/InP lasers is that the output power and threshold current are very temperature sensitive, the amount of leakage current increasing at high temperatures or high power. The effect has been considered by most researchers to be due to Auger recombination in the top InP layer. Incremental increases in the threshold current can be reduced by adding more Zinc in the top InP layer, thus cutting down the Auger recombination. However, with heavier Zn-doping the InP homojunctions which are in parallel to the laser cavity become leaky, and the output starts to saturate at low current. The power saturation problem was solved by fabricating the lasers with p-type substrates. In this structure the top contacting

layer is n-type which is two orders of magnitude higher in conductivity than p-type, and the leakage current through the InP homojunction is substantially reduced. A factor of three increase in output power has been observed on devices fabricated on the p-type substrates.

The last problem studied was the design of the mechanical fixture so that sufficient power can be dissipated without overheating when lasers or laser arrays are mounted together. Conventional approaches using laser arrays with cleaved cavities or stacking the lasers in series have all suffered two common drawbacks; difficult in assembly and emission of light from only one side of the cavity. Future packaging design should be concentrated on the planar geometry such that the laser light will emit from the device surface and from both sides of the cavities.

SUMMARY OF THE MOST IMPORTANT RESULTS:

- (1) Determination of the best growth temperature for GaInAsP lasers with emission wavelengths near 1.55 μm . An LPE growth temperature of 640C has been determined to be the best LPE growth temperature for 1.5 μm lasers in comparison with lower growth temperatures such as 600 and 560C.
- (2) Compositions (wavelengths) have been determined in the GaInAsP/InP DH lasers that can be grown with or without antimelt-back buffer layers. It was found that without antimelt-back layers DH lasers with wavelengths up to about 1.53 μm can be grown at 640C. With antimelt-back layers DH structures with wavelengths of 1.65 μm (GaInAs active layer

composition) have been grown using the LPE technique. DH lasers with emissions up to 1.57 um have been obtained with antimelt-back layers.

- (3) Optical powers up to 15 mW per facet at 100 ns pulse width have been achieved with oxide defined stripe (ODS) lasers lasing at 1.55 um. The optimum stripe widths for ODS lasers are 6-8 um with a threshold current of 200 mA.
- (4) BH lasers employing the thermal mass-transport technique have been achieved for the first time for 1.55 um lasers. Threshold currents between 20-40 mA and external differential quantum efficiencies greater than 0.14 mW/mA have been obtained.
- (5) Leakage currents caused by Auger recombination and "soft" InP homojunction have been identified. Leakage currents have been reduced by proper doping of Zn in the top InP layer and by proper control of the width of the InP homojunctions.
- (6) Further reduction of leakage and increase of output power has been achieved with the fabrication of lasers on p-type InP substrate. Output power, by using the p-type substrate, has shown a factor of three increase over that of the n-type.



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